U.S. DEPARTMENT OF COMMERCE
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PB-254 551-T

COMBINED CONVERSION OF POTATOES TO STARCH AND ETHYL ALCOHOL

ENVIRONMENTAL PROTECTION AGENCY

1959

161024

PB 254 551

BTR 76-171

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(Kompleksnaya pererabotka kartofelya na krakhmal
i etilovyy spirt)

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Spirtovaya Promyshlennost
Vol. 25, No. 6, 1959, pp. 25-28

Translated for EPA by
SCITRAN (SCIENTIFIC TRANSLATION SERVICE)
SANTA BARBARA, CALIFORNIA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC DATA SHEET	1. Report No. TR76-171	2.	3. Recipient's Accession No.
4. Title and Subtitle Combined conversion of potatoes to starch and ethyl alcohol.			5. Report Date 1959 6.
7. Author(s) Lishanin, P. Ye.			8. Performing Organization Rept. No.
9. Performing Organization Name and Address This translation from the Russian was done by the EPA.			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address Translations Section Library Services Environmental Protection Agency Research Triangle Park, N. C. 27711			13. Type of Report & Period Covered 14.

15. Supplementary Notes
Spirtovaya Promyshlennost, Vol. 25, No. 6, 1959, pp. 25-28.

16. Abstracts

17. Key Words and Document Analysis. 17a. Descriptors
EPAISD

17b. Identifiers/Open-Ended Terms
Soviet Union
Laboratory Technology

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
This translation was made from a non-copyrighted text.	UNCLASSIFIED	4
	20. Security Class (This Page) UNCLASSIFIED	22. Price 3.50

COMBINED CONVERSION OF POTATOES TO STARCH AND ETHYL ALCOHOL

by

P. Ye. Lishanin and Ya. A. Nagornyy

The XXI Congress of the Communist Party of the Soviet Union posed the task of complete utilization of raw resources and sharp reduction of the consumption of foodstuffs in the production of ethyl alcohol.

Potatoes in industry are primarily used in two branches — starch and alcohol (the vegetable drying industry requires only a small amount).

According to many years of data of the industry, the degree (factor) of potato starch utilization in alcohol production is 92.1-92.3% and in starch production — 80.0-81.2%, i.e. starch losses are: in alcohol production — 7.9-7.7% and in starch production — 20.0-18.8%.

If we convert this to absolute losses, then from each thousand tons of potatoes with average starch content of 18%, losses of absolutely dry starch are: in alcohol production — an average of 14.0 T, in starch production — 35.0 T.

The Ryazan Oblast produces a large amount of marketable potatoes for industrial processing. According to the prospective seven-year plan, the production of potatoes for industrial processing will increase from 200 to 350-400 thousand tons. The 17 alcohol plants existing in the oblast can process 1000-1100 T of potatoes per day and the 28 starch plants — 1250-1600 T. If it is assumed that about 60% of commodity potatoes will be converted into starch, then losses of absolute starch by the end of the seven-year period in the starch industry will be 7300 T, which converted to crude starch is 16.0 million rubles, or the cost of 10 modern starch plants processing 100 T of potatoes per day.

Reduction of these losses and their minimization is the duty of workers of the industry.

The best resolution of this question with the current state of technology in the starch and alcohol industries is combined conversion of potatoes to starch and alcohol.

The combined conversion of potatoes into starch and alcohol has been of concern in the USSR since 1930-1935. These works are also now being conducted. According to existing literature data and production surveys of the industry,

combined conversion of potatoes is being conducted in Czechoslovakia in an experimental plant in Zaborn and in a plant in Khinov according to the scheme developed at the Prague Scientific Research Institute of the Fermenting and Starch-syrup Industry by Doctor Mal'kher. According to this plant about 70% of the starch is extracted from potatoes and the remaining 30%, in a mixture with low-grade trapped starch and concentrated cell juice, is converted to alcohol. The output of the alcohol department in the first plant is 120 decaliters of alcohol in 8 hours and in the second — 80 decaliters.

The problem of more complete utilization of starch from potatoes was also of importance earlier, but its introduction was hindered by lack of connection between branches of the industry and great demands for industrial alcohol. With the creation of Economic Councils this dissociation disappeared and the resolution of the XXI Congress of the Communist Party of the Soviet Union on reduction of the expenditure of foodstuffs for the production of alcohol presents us with the task of immediate solution of this problem.

Two variants can be used in the combined conversion of potatoes to starch and alcohol: the organization in starch plants of departments to produce alcohol from residual starch in middlings and discarded cell juice, and the organization in alcohol plants of departments to produce raw starch and further process starch waste into alcohol in continuous distillation units.

The first version is complicated and expensive in volume of operation, equipment and expenditures and leads to additional production of alcohol for which there is now no great need.

The second variant is less complicated, does not require large capital expenditures for equipment or large industrial premises. It is quite feasible in almost all alcohol plants especially those having equipment for continuous processing of starch raw material.

The purpose of the department to produce crude starch is to extract 50-60% of the starch from processed potatoes and convert the remaining starch with significant amounts (up to 40%) of cell juice to alcohol. The utilization of potato starch with existing still unavoidable losses in starch and alcohol plants is increased to 95-96%, which is evident from the following calculation: with 18% starch content of potatoes, 50% of the starch is extracted in the starch department, or 9 kg out of 100 kg of potatoes. Conversion of the remaining 9 kg of starch to alcohol produces a yeild of 92%. Thus, 8.28 kg (9 x 0.92) is converted to alcohol. A total of 17.28 kg = (9.0 + 8.28) of starch is utilized. The starch utilization factor will be

$$\frac{17.28 \cdot 100}{18.0} = 96\%.$$

We devised a plan for the combined conversion of potatoes to starch and ethyl alcohol (Fig. 1).

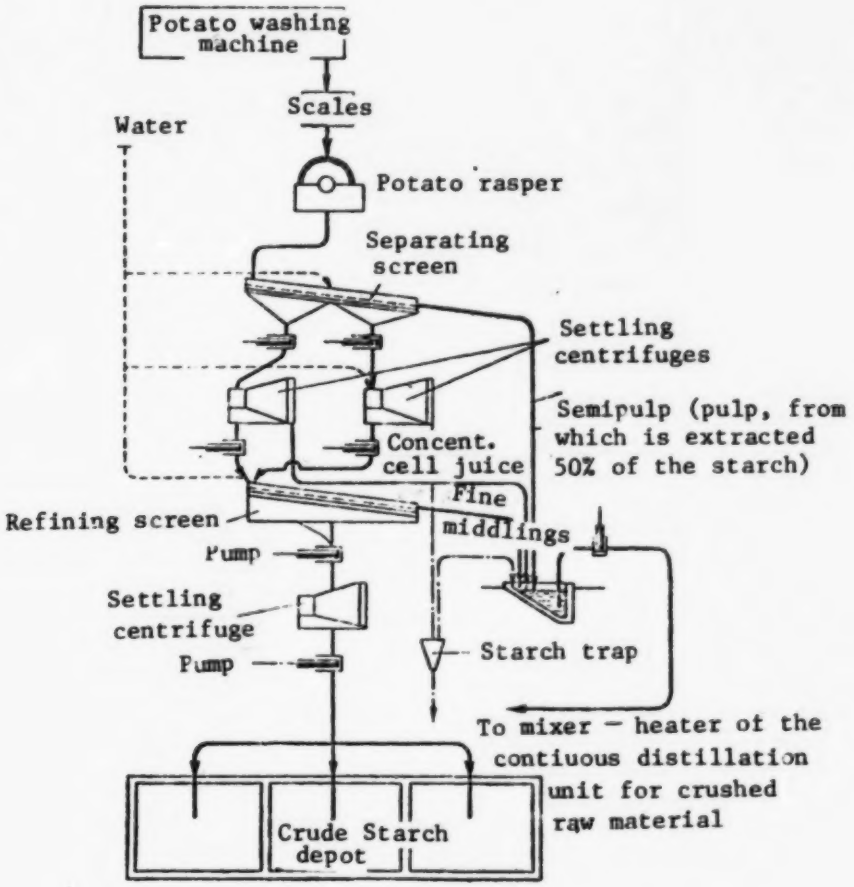

Figure 1. Flow diagram of combined conversion of potatoes to starch and ethyl alcohol.

In plants this plan begins at the first pair of shaker seives, as in plants with continuous distillation units for starch raw material washing and rasping units are necessarily present; where they are lacking, this plan will begin with the rasping unit.

We also recommend a high-speed potato rasper able to process 60 or 100 T of potatoes per day (ST-60 or ST-100), depending on the capacity of the plant.

The potatoes are to be crushed to the degree that they provide the necessary extraction coefficient of 50-60% of the starch and in addition produce a minimum amount of fine middlings.

To improve movement of pulp from under the rasper it is necessary to add water. We suggest that 20-25% water (according to the weight of the potatoes) will ensure movement of the pulp through the pipes. Starch will be extracted from the pulp in two parallel shaker seives operating at 1200 revolutions per minute. In order to obtain concentrated cell juice the seive is conventionally divided into two parts. It is contrived so that the first part of the seive receives the whole pulp with its starch and cell juice plus the water added to the hopper under the rasper. The aim is to obtain in this part of the seive the maximum amount of cell juice with a minimum content of starch; therefore, no water is provided to this part of the seive for spraying the pulp.

The second part of the seive is intended to obtain the necessary amount of starch. This part of the seive is profusely sprayed with water, calculated so that the density of the resulting starch milk is 2.5-3°. Water in the amount of 100-120% of the weight of the processed potatoes is required, depending on the starch content. The seive is lined with No. 30-40 serge mesh.

Starch is separated from cell juice in the settling centrifuges. The suspension from the first part of the seive is directed to one centrifuge, and that from the second part to the second. This separates concentrated cell juice, which is directed from the seives to the semipulp (middlings) collector for later conversion to alcohol. Juice water from the second centrifuge is directed to a starch trap installed outside the plant building.

Separated starch in the first and second centrifuges with a density of 23-25° reaches the common starch collector, from which it is fed by a displacement pump to a second pair of seives for refining. The refining seives are lined with No. 35-38 silk mesh. The fine middlings separated in refining are sent to the common middlings collector and the starch milk to the settling centrifuge for condensation. The emerging starch milk with a density of 35-38° Br is sent to the crude starch depot and washing water to common starch traps.

Coarse middlings from the separating shaker seives, fine middlings from refining seives, concentrated cell juice and starch from the traps are sent in mixed form to the continuous distillation unit for conversion to alcohol.

A crude starch section in an alcohol plant, according to the suggested plan, requires: 4 high-speed shaker seives (1200 rpm), 2 OTs-25 settling centrifuges, 1 OTs-50 settling centrifuge and 7 displacement pumps.

As seen from the plan for the arrangement of technological equipment (Fig. 2) in the starch department of an alcohol plant, the total area of the department is about 100 m^2. Power requirements for auxiliary equipment to the

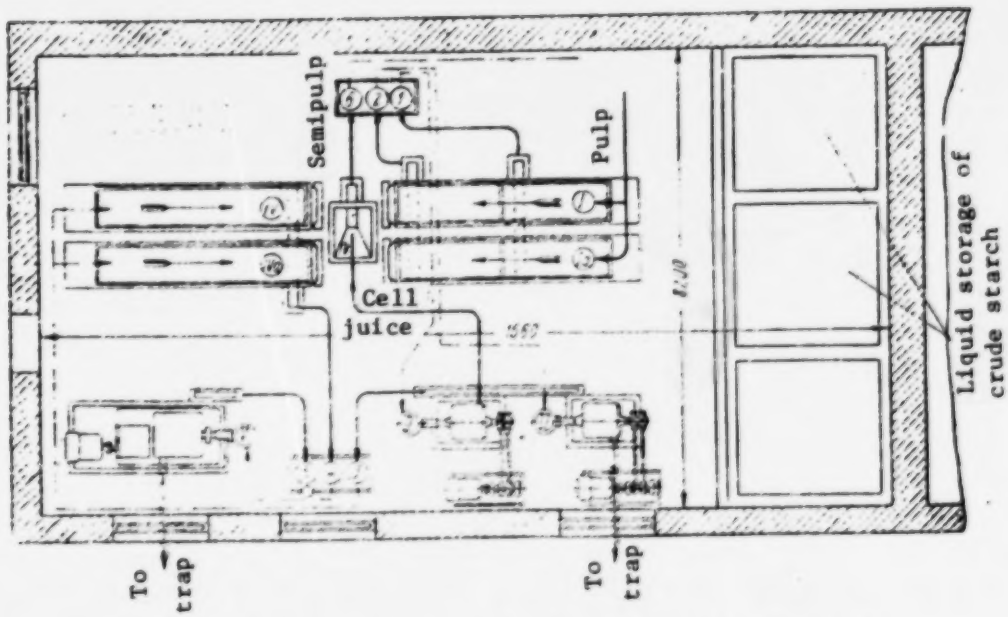

Figure 2. Arrangement of technological equipment in the starch department of an alcohol plant:

1, 2, 3, 4, 5, 6 – displacement pumps, I, Ia and IV, IVa – flat seives; II, III – OTs-25 settling centrifuges; V – OTs-50 centrifuges.

starch department of an alcohol plant processing 100 T of potatoes per day do not exceed 60 kw.

The question of the alcohol part of a combined plant is raised especially. With the usual scheme of starch production with 82% extraction from potatoes and dilution of cell juice in starch-washing equipment the amount of material discarded in waste (starch and sugar) does not exceed 1.5-2.0%.

Processing of this waste reduces the productivity of the alcohol plant 5-6 times with the same expenditures and significantly raises the cost price of alcohol. Such a scheme will not be economically profitable. This is why the plan developed by the Food Industry Administration of the Ryazan Economic council specifies extraction of 50-60% of the starch with simultaneous sampling of cell juice. In this case the concentration of discarded material reaches 4.5-5%. This is also low, of course, as the alcohol content of spirits will vary between 2.5-3%, also raising the cost price of alcohol.

The plan for continuous distillation of starch raw material devised and in practice carried out in a number of alcohol plants in the Ryazan alcohol trust makes it possible to process starch products in mixed form at the same time, regardless of their nature.

Therefore, to ensure profitable operation of the alcohol part of the plant we recommend adding to starch production residue 25-30% grain raw material of the weight of processed potatoes. This will produce an alcohol content in spirits of 7-7.5%. In practice this is easy to accomplish, as every alcohol still processes significant amounts of imperfect grain raw material.

The most important question in combined conversion of potatoes to starch and alcohol is economic effectiveness. According to our calculations this is also resolved positively. Combined processing specifies increased output of marketable products with the same expenditures of raw material as in ordinary operation of the plant. We slightly reduce the output of marketable alcohol but thereby obtain a product which is more profitable for the plant and more necessary for the country — starch.

Adaptation of the factory, equipment and assembly require a maximum of 200 thousand rubles. In processing 6200 T of potatoes the plant produces 1050 tons of crude starch and accumulates 470.0 thousand excess rubles, compensating in one year all the expenditures for installing the starch department. These excess profits are gained from the reduction of the cost price per ton of starch produced in the starch department of the alcohol plant as compared with that of an ordinary starch plant.

In the first case profits are 1670 rubles 83 kopecks and in the second — 2275 rubles 96 kopecks, or a difference per ton of 605 rubles 06 kopecks, for the entire production — 90.5 thousand rubles and because of the significant increase in the commodity price of the production, from the same amount of raw material — 382.5 thousand rubles.

Therefore, from an economic point of view as well, these measures are profitable.

In the Ryazan economic region this year the Verderev, Pokrovo-Shishkinsk and Klyuchan alcohol plants are being converted to combined processing of potatoes. Of course, there will be difficulties developing in the production process, especially in process control. Scientific-research institutes of the alcohol and starch-syrup industries must offer practical assistance to these plants.